Vegetation and climate in Garhwal Himalaya during EarlyHolocene : Deoria Tal

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Pollen analysis of 1.5 m deep profile from the western flank of Deoria Tal (Profile-II), situated in temperate belt of Garhwal Himalaya has unravelled the vegetation and climate of Early Holocene. The vegetation, traced back to about 6000 years and ^{14}C dated 2710 ± 150 years at 55-65 cm depth, comprised chiefly the Oak dominated forests associated with other broad-leaved taxa such as *Betula, Alnus, Rhododendron, Carpinus, Ulmus*, etc. Such an arboreal forest composition reflects warm-temperate humid climate prevalent in the region. A change to cooler climatic conditions is registered between 3500-3600 years B.P., as evidenced by the decline in Oak — the chief component, as well as in other associated broad-leaved elements with a corresponding rise in grasses and sedges. Anthropogenic activities are also recorded during this period, inferred by the first appearance of Cerealia- type pollen and encountered culture pollen. Subsequently, around 1,700 years B.P., restoration process of Oak forests commenced, thus indicating the amelioration in climatic conditions.

Key-words — Palynology, Palaeovegetation, Palaeoclimate, Garhwal Himalaya, Early-Holocene, India.

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सारांश

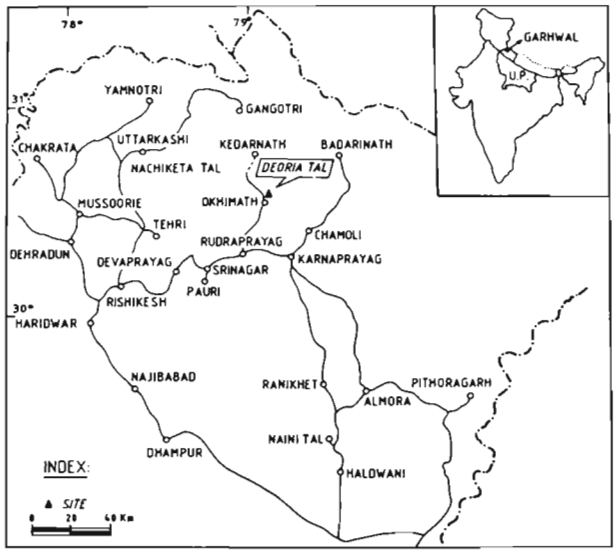
देवरिया ताल : प्रारम्भिक होलोसीन काल में गढ़वाल हिमालय में वनस्पति एवं जलवायु

छाया शर्मा एवं आशा गुप्ता

गढ़वाल हिमालय में शीतोष्ण क्षेत्र में स्थित देवरिया ताल (परिच्छेदिका- 2) के पश्चिमी तट से 1.5 मीटर गहरी परिच्छेदिका के परागकण विश्लेषण से प्रारम्भिक होलोसीन काल में विद्यमान वनस्पति और जलवायु के बारे में महत्वपूर्ण जानकारी मिली है। उपलब्ध वनस्पति, जो लगभग 6000 वर्ष पुरानी तथा कार्बन ^{14} द्वारा 2710±150 वर्ष की कालनिर्धारित की गई है, में *बिटुला, एल्नस, रोडोडेन्ड्रॉन, कार्पाइनस, अल्मस* आदि चौड़ी पत्तीयों वाले वर्गकों से सहयुक्त तथा मुख्यतया ओक से प्रभावी वर्गक विद्यमान हैं। इस प्रकार वृक्षीय वनस्पति की उपस्थिति से इस क्षेत्र में उष्णशीतोष्ण और नम जलवायु का होना प्रस्तावित होता है। लगभग 3500–3600 वर्ष पूर्व ओक की संख्या में कमी तथा घासों और सेजों की संख्या में वृद्धि से कुछ ठंडी जलवायु परिवर्तन के संकेत मिलते हैं। इसी अवधि में मानव गतिविधियों के भी संकेत मिले हैं। इसके पश्चात् लगभग 1,700 वर्ष पूर्व पुनः ओक से प्रभावी वनों में वृद्धि हो गई, जिससे जलवायवी परिस्थितियों में पुनः सुधार प्रदर्शित होता है।

GARHWAL Himalaya, the region lying between Himachal Pradesh and Kumaon Himalaya, received little attention to decipher the Quaternary vegetation and climate. However, Sharma (1985b) and Gupta and Sharma (1993) investigated the surface samples from the region to assess the pollen/vegetation relationship. Sharma and Gupta (1995) also carried out the pollen analysis of lacustrine sediments from Nachiketa Tal, situated in Uttarkashi District of Garhwal region and unravelled the palaeovegetation and corresponding climate since 1500 years B.P. Similar palynostratigraphical studies extended to cover Chamoli District in Garhwal region deal with recently investigated two profiles from Deoria Tal, i.e., Profile-I, dug out from a 3 m deep trench on the eastern flank of the lake (Sharma *et al.*, in press) and the present Profile-II to a depth of only 1.5 m from the western flank.

Deoria Tal is situated at an altitude of 2,727 m on Chopta-Ukhimath road, about 4 km from Sari Village between 75° 5' Long. and 30° 5' Lat. in Chamoli District (Text-figure 1). The lake is almost circular in outline having a circumference of about 150 m and is held sacred by local people.



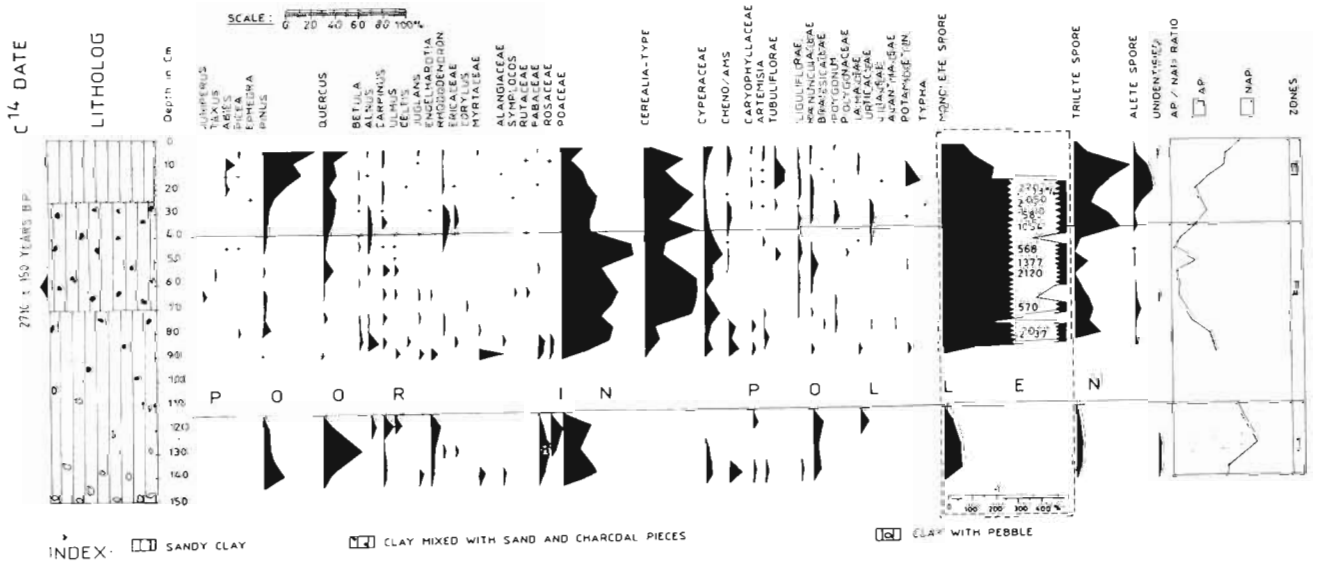
Text-figure 1—Sketch map showing location of Deoria Tal, Garhwal Himalaya.

VEGETATION

Deoria Tal lies in the temperate vegetation belt having broad-leaved mixed Oak forests all around. These forests predominantly consist of *Quercus semecarpifolia* associated with *Rhododendron arboreum, Alnus nepalensis, Ulmus wallichiana, Aesculus indica, Acer caesium, Engelhardtia vellutianum, Myrica esculenta, Pyrus malus,* etc. Commonly seen shrubby elements are—*Rubus ellipticus, Rosa* spp., *Berberis asiatica, Viburnum cotinifolium, Woodfordia fruticosa, Carissa spinarum*, etc. The herbaceous ground cover is quite gregarious showing prominence of grasses. Other noteworthy herbaceous components belong to Chenopodiaceae, Amaranthaceae, Polygonaceae, Asteraceae, Brassicaceae, Caryophyllaceae, Ranunculaceae, etc. contributing to the local thick ground vegetation cover.

MATERIAL AND METHODS

The present 1.5 m profile was dug out from the western flank of Deoria Lake. Since the lake is without any muddy or marshy margin, Hiller Peat Auger could not be operated for the required profile. Sampling was done at 5 cm interval from 0-100 cm depth and then from 100-150 cm at 10 cm interval of the lithocolumn, beyond which the column had a thick deposit of pebbles. Pollen and spores were retrieved following the usual procedure (Erdtman, 1943), using KOH, HF and acetolysis. Frequency percentages of recovered taxa have been calculated in terms of total terrestrial pollen.



Text-figure 2—Pollen diagram from Deoria Tal, Garhwal Himalaya (percentages calculated in terms of total terrestrial pollen).

LITHOSTRATIGRAPHY

The collected profile does not exhibit well demarcated stratifications and composed of sandy clay, clay mixed with sand, charcoal pieces and embedded pebbles.

The lithological details are as below :

0-25 cm - sandy clay
25-70 cm - clay mixed with sand and charcoal pieces
70-100 cm - clay with charcoal pieces
100-150 cm - clay with pebbles

RADIOCARBON DATE

The profile is radiocarbon dated 2710 ± 150 years B.P. at 55-65 cm depth. The samples from 100-120 cm depth failed to yield sufficient carbon contents required for another dating of the sample.

POLLEN ANALYSIS

Based on the pollen frequency fluctuations observed in case of significant elements, the pollen diagram (Text-figure 2) has been divided into three palynoassemblage zones and the vegetational succession is discussed from bottom of the lithocolumn upwards.

Zone-I (150-115 cm) : *Quercus-Pinus-Carpinus-Engelhardtia*-Fabaceae-Rosaceae, Poaceae-Ranunculaceae Assemblage Zone—The vegetational sequence begins with mixed Oak forest demonstrating the dominance of *Quercus* (9-34%), followed by *Pinus* (5-18%), *Carpinus* (3-9%) and *Engelhardtia* (2- 9%). Other arboreal taxa such as *Alnus* (5%), *Ulmus* (4%), *Juglans* (3%), Myrtaceae (6%), Alangiaceae (3%), *Rhododendron* (2%), *Betula* (1%), etc., are encountered in comparatively very low values. Shrubby elements belonging to Fabaceae (5-25%), are well represented throughout this zone followed by Rosaceae (4-9.5%).

Among nonarboreal elements, Poaceae (14-27%) dominate over the rest, Ranunculaceae (4-9%) is next in continued dominance though Cheno/Ams reach a value of 12 per cent but disappear around the middle of this zone. Other components of vegetation are Cyperaceae (2-6%), Caryophyllaceae (3-4.5%), Lamiaceae (8.5%), *Artemisia* (3%) and Liguliflorae (3%). Fern spores (monolete 66% and trilete 6%) encounter consistently throughout the zone. The overall AP/NAP ratio denotes the existence of mixed broad-leaved Oak forests in the region.

Zone-II (115-40 cm) : Poaceae-Cyperaceae-Fern Assemblage Zone—This middle zone towards the base between 115-90 cm depth is palynologically barren but the subsequent reconstructed vegetation above 90 cm is marked by the abrupt change in the vegetation compared to the scenario witnessed in preceding zone. Hence, the vegetation sequence gets discontinued at the beginning of this zone. *Quercus* exhibits a steep decline in its values, followed by *Pinus*. These two components are reduced to only 0.5-4 per cent and 0.5-6.5 per cent respectively. *Carpinus* and *Engelhardtia* also decline to 5-6.5 per cent each. *Alnus, Ulmus, Juglans, Betula*, Ericaceae and Alangiaceae, however, maintain more or less the same values as witnessed in previous zone. *Celtis, Corylus, Symplocos, Abies, Picea, Taxus, Ephedra* and *Juniperus* though with low frequencies make their first appearance in this zone.

Shrubby elements also exhibit a declining tendency as Fabaceae and Rosaceae are represented by 4-5 per cent and 2-2.5 per cent respectively towards the base. They further reduce to 1 per cent, and ultimately not represented at the top. Rutaceae makes its first appearance towards the top of the zone.

Nonarboreals (79-97%) flourished remarkably well during this zone showing distinct dominance of Poaceae (32-60.5%), followed by Cerealia type (4-44%). Cyperaceae has fluctuating position in this zone, though acquiring position next to Poaceae having 2.5-16 per cent values, dwindling down around the middle and soon regaining a high frequency later on. Relatively, *Artemisia* also appreciates with values increasing up to 5 per cent. Tubuliflorae (5%), Brassicaceae (2%), Polygonaceae (.5- 2%), Urticaceae (1-2%) and Acanthaceae (2%) are sporadic but new additions to the ground floristic composition. Cheno/Ams and Caryophyl-

laceae maintain more or less the same values as witnessed in earlier zone, whereas both Ranunculaceae and Lamiaceae are reduced to 1-7 per cent and 0.5-2 per cent respectively. Aquatic vegetation is registered by the poor representation of *Potamogeton* (1-4%).

Monolete fern spores abruptly get enhanced values compared to previous zone and trilete spores reach up to 23 per cent. Alete spores also appear in this zone with frequency up to 6 per cent. The overall AP/NAP ratio reflects open type forested conditions as compared to Zone-I

Zone-III (40-0 cm) : *Quercus-Pinus-Rhododendron* Poaceae Assemblage Zone—In this uppermost zone, arboreals (21- 58%) have an overall good representation reaching almost same values as already witnessed in Zone-I. *Quercus* gradually improves, demonstrating 22 per cent values at the top whereas *Pinus* surprisingly attains all time high values of 43 per cent from middle onwards in the zone. Another conifer *Abies* (2-7%) also registers a marked increase in the frequency at the upper part of the zone. *Rhododendron* alongwith other members of Ericaceae also get enhanced reaching 6 per cent and 4 per cent values respectively, whereas *Betula, Alnus, Carpinus, Celtis, Juglans, Picea, Symplocos* and Alangiaceae, etc., maintain more or less same values as seen in preceding zone but for *Engelhardtia* which declines. *Aesculus, Myrica* and *Salix* pollen are meagre. Also the values of shrubby elements, viz., Fabaceae, Rosaceae and Rutaceae are further reduced to 10.5-1 per cent, compared to their representation witnessed in the above zone.

Among the nonarboreals, Cerealia-type pollen acquire the most dominant position, reaching up to 45 per cent values and bringing Poaceae (9-29%) down to a subordinate position, particularly in the upper part. Cyperaceae (1.5-8%) also registers a distinct reduction in contrast to Zone-II. Similarly, Brassicaceae (10.5%), Cheno/Ams (0.5-4%), Caryophyllaceae (0.5-1.5%), *Artemisia* (0.5-1.5%) and Ranunculaceae (1-3%) too decline in their relative frequencies. Tubuliflorae (1-9%), Liguliflorae (1-4%), *Polygonum* (0.5-4%) and Urticaceae (1-4%) are better represented. Lamiaceae maintain more or less the same values as witnessed in Zone-II and Liliaceae pollen encountered for the first time in this zone. Aquatic vegetation is better represented with relative improvement in the frequency of *Potamogeton* (4-17%) in addition to the appearance of *Typha*.

Monolete spores maintain their extremely high values at the commencement of this zone but from the middle of the zone upwards gradually dwindles down (290-88%). Trilete and alete spores are encountered in high values (3-47% and 1-18%) than seen earlier. AP/NAP ratio reflects to the re-establishment of Oak forests in the region.

VEGETATION AND CLIMATE

The investigated lacustrine sediments from western Himalaya cover Himachal Pradesh (Sharma, 1985a; Sharma & Chauhan, 1988a; Sharma & Singh, 1974a, b; Bhattacharyya, 1988) and Kumaon Himalaya (Vishnu-Mittre *et al.*, 1967; Gupta, 1977; Gupta & Khandelwal, 1982; Sharma & Chauhan, 1988b; Chauhan & Sharma, 1996).

Similar palynostratigraphical studies have recently been carried out to generate proxy-climate signals for Garhwal Himalaya. The investigated 2 m deep profile from Nachiketa Tal—a lake situated in temperate zone of Uttarkashi District (Sharma & Gupta, 1995) and another 5 m deep profile from Chharka Tal (one amongst the conglomerate of seven lakes) though again from Uttarkashi region but situated in subalpine belt (Chauhan *et al.*, in Press) have unravelled the palaeovegetation and corresponding climate of Late-Holocene. In addition, two more profiles from the opposite flanks of the same lake situated in the temperate belt of Chamoli District in Garhwal Himalaya have been investigated. A 3 m deep Deoria Tal-I profile from the eastern flank was investigated earlier by Sharma *et al.* (in Press).

The present paper deals with the study of Deoria Tal-II profile from western flank unfolding the vegetation succession during the Early-Ho-

locene. It is ^{14}C dated 2710+150 years B.P. at 55-65 cm depth, but based on lithostratigraphy and reconstructed vegetation of the earlier investigated Deoria Tal-I profile, the bottom of the present lithocolumn could be extrapolated to reveal the palaeovegetation of about 6000 years B.P.

The emerged vegetation history in Deoria Tal-II begins with well established Oak dominated forests in the region. The occurrence of *Pinus roxburghii* pollen in appreciable numbers, when it does not grow these days at this elevation, is the well established case of pseudorepresentation. These were transported from the lower mountain slopes where good chirpine forests exist. Sharma (1985b) and Gupta and Sharma (1993) have already pointed about this phenomenon of *Pinus* presence in such palynostratigraphical studies carried out in the Himalayas.

However, *Carpinus* and *Engelhardtia* — the two associates of *Quercus* together with Ericaceae, *Juglans*, Rosaceae, *Betula, Alnus* and *Ulmus* have a sporadic distribution in these forests. Ground vegetation was poor, dominated by Poaceae alongwith Ranunculaceae and feebly represented Cyperaceae, Cheno/Ams, Caryophyllaceae, etc. The overall emerging vegetal scenario demonstrates that the region during this period had warm-temperate humid climate as also indicated by the large number of encountered fern and other spores .

The vegetation of the period between 4600-3600 years B.P. remains concealed in the lithocolumn at 115-90 cm depth as the sediments did not yield sufficient pollen. However, *Quercus, Pinus, Ulmus* and Ericaceae have been recovered in poor numbers besides pollen of Poaceae, Cheno/Ams, *Potamogeton* and monolete fern spores.

Later, around 3600 years B.P., there was a catastrophic decline in the density of *Quercus* as well as other broad-leaved associates. *Carpinus* and *Engelhardtia* also declined. Thus, an over all reduction in the density of forests is witnessed in the region associated with corresponding abrupt rise in the ground vegetation cover indicated by appreciated values of Poaceae and Cyperaceae on one hand and the enhancement in Cerealia-type pollen with first appearance of several culture pollen on the other. Such a change in the vegetation scenario reflects a change in the climate to cooler and humid conditions as evident by exceptionally high frequencies of fern and other spores. Abundance of culture pollen, particularly the Cerealia-type, and presence of charcoal pieces in the sediment indicate intensive agricultural activities in the region.

The above phase continued till around 1700 years B.P., after which the restoration of forests is witnessed as evidenced by prominent increase in *Quercus* and its associated arboreals. Marked increase in the values of *Rhododendron* and other members of Ericaceae is also indicative of the commencement of such a change in the vegetation scenario. Continued appreciated values of Cerealia-type and other culture pollen further indicate well established agriculture in the vicinity of the lake. The recorded rise in the frequencies of arboreals and corresponding fall in nonarboreals during this phase is indicative of regeneration process of forests under ameliorated climatic conditions.

Comparison of two investigated profiles— Deoria Tal-I and Deoria Tal-II, have portrayed more or less identical picture of palaeovegetation succession. Vegetational history in the two is traced back to ± 4000 years B.P., in case of former and extrapolated to ± 6000 years B.P. in the later which begins with the existence of Oak dominated forests. Subsequent decline of these forests took place between 3500-4000 years B.P., and continued till around 1700-1800 years B.P., thereafter, the Oak forests were restored. These three palaeovegetation phases indirectly reflect to the warm-temperate humid climate under which these forests initially flourished in the region, followed by a change to cool temperate humid climate when Oak forests diminished and grass cover simultaneously increased. The climate once again changed to earlier warm-temperate humid conditions resulting into the restoration of the existing Oak forests in the region.

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REFERENCES

Bhattacharyya A 1988. Vegetation and climate during Post glacial period in the vicinity of Rohtang Pass, Great Himalayan Range. *Pollen Spores* **30** : 417-427.

Chauhan MS & Sharma C 1996. Pollen analysis of mid-Holocene sediments from Kumaon Himalaya. *Proc. Symp. NW Himalaya & Foredeep, Geol. Surv. India Spl Publ.* : 257-269

Chauhan MS, Sharma C & Rajagopalan G (1997. Vegetation and climate during Late-Holocene Period in Garhwal Himalaya. *Palaeobotanist* **46**(1,2) : 211-216.

Erdtman G 1943. *An introduction to pollen analysis*. Chronica Botanica Co., Waltham, Mass.

Gupta A & Sharma C 1993. Recent pollen spectra from Nachiketa Tal, Garhwal Himalaya. *Geophytology* **23** : 155-157

Gupta HP 1977. Pollen analytical reconnaissance of Post glacial deposits from subtropical zone in Nainital District, Kumaon Himalaya. *Palaeobotanist* **24** : 215-244.

Gupta HP & Khandelwal A 1982. Late Holocene palynology from the Lake in Sat Tal Valley, district Nainital, Kumaon Himalaya, U.P. *Geophytology* **12** : 313-321.

Sharma C 1985a. On the Late Quaternary vegetational history in Himachal Pradesh-3. Parasram Tal. *Geophytology* **15** : 206-218.

Sharma C 1985b. Recent pollen spectra from Garhwal Himalaya. *Geophytology* **15** : 87-97.

Sharma C & Chauhan MS 1988a. Studies in the Late-Quaternary vegetational history in Himachal Pradesh-4. Rewalsar Lake-II. *Pollen Spores* **30** : 395-408.

Sharma C & Chauhan MS 1988b. Palaeoenvironmental inferences from the Quaternary palynostratigraphy of Himachal Pradesh and Kumaon, India. *Proc. Indian natn. Sci. Acad.* **54A** : 510-523.

Sharma C & Gupta A 1995. Vegetational history of Nachiketa Tal, Garhwal Himalaya, India. *J. Nepal geol. Soc.* **10** : 29-34.

Sharma C, Chauhan MS & Rajagopalan G (in Press). Vegetation and climate in Garhwal Himalaya during last 4,000 years B.P. *J. Nepal geol. Soc.*

Sharma C & Singh G 1974a. Studies in the Late Quaternary vegetational history in Himachal Pradesh-1. Khajiar Lake. *Palaeobotanist* **21** : 144-162.

Sharma C & Singh G 1974b. Studies in the Late Quaternary vegetational history of Himachal Pradesh-2. Rewalsar Lake. *Palaeobotanist* **21** : 321-338.

Vishnu-Mittre, Gupta HP & Robert RD 1967. Studies of the Late Quaternary vegetational history of Kumaon Himalaya. *Curr. Sci.* **36**: 539-540.